



## SOIL GAS SAMPLING AND FIELD ANALYSIS

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**USE CATEGORY 2**

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## 1.0 PURPOSE

This standard operating procedure (SOP) describes procedures that will be used at the Rocky Flats Environmental Technology Site (RFETS) to conduct soil gas field surveys or headspace measurements of organic vapors in environmental samples. It also provides procedures for dynamic and passive collection of soil gas samples to be used in identifying volatile organic compounds (VOC) present at Individual Hazardous Substance Sites (IHSS) on the Rocky Flats Environmental Technology Site (RFETS). The requirements for application of these procedures to a given site will be specified in applicable project plans.

## 2.0 SCOPE

This document, which supersedes procedure SOP OPS-GT.09, applies to all RMRS personnel and subcontractors conducting soil gas sampling and field analysis activities at the RFETS.

Soil gas sampling and field analysis will be performed at sites identified in an approved work plan or other work-controlling document. This document defines the personnel qualifications, materials and equipment required to perform soil gas sampling, instrument calibration requirements, sampling procedures, and the documentation of all field data.

## 3.0 REQUIREMENTS

A RMRS or subcontractor representative with experience in soil gas sampling and field analysis will conduct oversight and supervision of any field operations that will provide for the sampling of soil samples for field gas analysis of volatile organic compounds (VOCs).

Only qualified personnel will be allowed to operate portable gas chromatographs (GCs) or vehicle-mounted GCs in mobile laboratories. Required qualifications vary depending on the activity to be performed. In general, qualifications will be based on education, previous experience, on-the-job training, and supervision by qualified personnel. The subcontractor's project manager will document personnel qualifications related to this procedure in the subcontractor's project QA files.

### 3.1 Personnel Qualifications

Personnel performing VOC field surveys, and/or monitoring with a flame ionization detector (FID) or photoionization detector (PID) portable vapor meters, and/or collecting soil gas samples will be scientists, engineers, or field technicians with appropriate field experience and training provided under the supervision of another qualified person.

Personnel performing these procedures are required to have completed the initial 40-hour OSHA classroom training that meets Department of Labor Regulation 29 CFR 1910.120(e)(3)(i), and must maintain a current training status by completing the appropriate 8-hour OSHA refresher courses.

Prior to conducting any soil gas sampling and field analysis operations, personnel are required to have a complete understanding of the procedures described within this and certain related SOPs. Personnel will receive specific training regarding these procedures as necessary.

### 3.2 Materials and Equipment

Soil gas sampling can be accomplished through the use of a variety of equipment. The following is a list of equipment and materials that may be required to perform soil gas sampling and field analysis.

- Portable PID or FID
- Calibration gas standards of known concentration
- Split spoon sampler, hand auger, or other sampling apparatus
- Push soil sampler equipment (Geoprobe® or equivalent)
- Wide-mouth sample jars with screw-cap lids
- Aluminum foil
- Retractable point soil gas sampler for push type sampler
- Large bore or macro-core sampler for push type sampler
- Granular bentonite
- Deionized or distilled water
- Vacuum pump with gage to extract soil gas
- Gas collection bags or tubes (if required)
- Gas sample syringe (if required)
- Gas chromatograph and/or mass spectrometer (if required)
- Petrex® tubes
- Field data forms (as applicable)
- Black waterproof pens
- Appropriate health and safety equipment

#### 4.0 PROCEDURES FOR SAMPLING AND FIELD ANALYSIS

The concentration of a VOC in soil gas is a complex function of the distribution of the organic compound and its interaction with the soil. This interaction depends on a number of soil parameters including soil particle size and mineralogy, soil lithology, heterogeneity, organic content, moisture, and temperature.

Volatile organic contaminants in soils above the water table (vadose zone) can be present in the gas phase in unsaturated pore spaces, in the water contained in the unsaturated soils, and sorbed on the soil particles. The VOC contamination is the sum of the VOCs contained in all three phases. The partitioning of the VOC between gas, liquid, and adsorbed phases is dependent on both the soil properties and the chemical properties of the compound. Thus, given the chemical properties of the VOC and measurements, or reasonable estimates, of relevant soil parameters, soil-gas data can be used to provide semiquantitative estimates of the VOC contamination in soils.

The sampling and analysis of soil gas can be used as a rapid field screening technique for health and safety evaluations of potentially contaminated soils, to aid in the placement of monitoring wells, to identify VOCs, to evaluate the areal extent of soil contamination, and to estimate the effectiveness of remedial measures.

The sampling and analysis of soil gas can be performed by several different methods. A field survey of work sites and materials can be performed using a portable organic vapor meter. The field survey provides information on total organic vapor concentrations in the air around the work site. A more detailed analysis on the location of VOC contaminated soil may be accomplished by performing field measurements of soil headspace samples. This technique allows the measurement of the total organic vapor concentration from a specific soil sample. Soil gas samples may also be obtained by pumping directly from a probe inserted in the ground, collecting the gas, and analyzing it. This technique of in situ soil gas sampling allows for the identification and quantification of specific volatile organic compounds.

This procedure will discuss the methods used for the following types of soil gas surveys:

- Field surveys
- Field measurements of headspace samples
- In situ soil gas sampling
  - Dynamic
  - Passive

#### 4.1 Field Surveys

Field surveys of work sites, site activities, and site materials for volatile organic vapors will be accomplished by using direct reading instruments, such as the photoionization detector (PID) portable vapor meter and the flame ionization detector (FID) portable vapor meter. Field surveys will be used as rapid field screening techniques for health and safety and for site evaluation before and during the excavation of potentially contaminated soil. These procedures may be used to aid in the placement of monitoring wells, and in the evaluation of the areal extent of soil contamination.

##### 4.1.1 *Instrument Calibration and Operation*

PIDs and/or FIDs will be used according to the procedures contained in SOP FO.15, Photoionization Detectors and Flame Ionization Detectors. Instrument operational and calibration requirements will comply with the manufacture recommendations. Calibration of instruments involved in soil gas analysis shall occur at the beginning of each working day and, after that, continuing calibration verification shall be performed every eight hours or after a batch of 20 samples, whichever is more frequent.

A factor which will affect total organic vapor concentration measurements is the type of detector that is used (e.g., FID vs. PID). Generally, the FID will be most appropriate for aliphatic hydrocarbons and certain oxygenated solvents while the PID will be more sensitive to aromatic and halogenated hydrocarbons. PID lamps of different ionization energies will respond with varying degrees of sensitivity to the same gases, and are significantly affected by high humidity. Generally, the FID response is proportional to the number of carbon-hydrogen bonds, and can, therefore, be used to estimate concentrations of total hydrocarbons.

##### 4.1.2 *Survey Procedures*

The following procedures will be used to measure compounds detectable by PIDs and/or FIDs in performing field surveys:

1. Check the battery charge. Batteries should be recharged for the time frame specified in the operating manuals for both the PID and FID instruments. Usual length of operating time between charges is 8 to 12 hours.
2. FID fuel and/or combustion air-supply gauges should be monitored to ensure sufficient gas supplies.
3. Hold instrument probe close to the area to be sampled. The low flow-sampling rate of the instrument provides only localized readings. Use a slow, sweeping motion to prevent the bypassing of variable concentration areas, and to allow for instrument response lag time.

4. Record observations, PID and/or FID measurements, source location, and description, date, time, weather, sample ID, operator, and other pertinent information in the field log book. Perform routine maintenance, as described in detail in the operating manual. Clean the sample probe and/or in-line filters (in front of detector) when high background readings are exhibited after prolonged use. Use of pipe cleaners or clean air blown backward through filters is normally adequate. Do not use organic solvents.

#### 4.2 Field Measurements of Headspace Samples

The field analysis of soils for organic vapors can be enhanced by obtaining a sample of contaminated soil, placing the soil sample in a confined space, and allowing volatilization of organic compounds, followed by collection of a sample of the air space above the soil sample. This is referred to as headspace analysis, and is accomplished by half-filling a sample container with a soil sample to be analyzed. VOCs present in the soil pores will diffuse into the remaining unfilled air space within the container. Physical characteristics of the soil (e.g., temperature, grain size, moisture content, organic carbon content) may have a significant effect on the headspace analysis results, and, therefore, estimates of these parameters should be recorded at the time the measurement is taken. If a PID or FID is used for the headspace analysis, record the results on the appropriate forms, Form PRO.121A or PRO.121B.

Headspace analyses are useful in that they can provide real-time data to aid in soil removal operations, where decisions regarding the extent of soil excavation and its disposal must be determined on-site. In addition, headspace analyses of soils encountered during investigations can be screened for health and safety purposes.

##### 4.2.1 *Equipment*

The following equipment will be required to collect headspace samples and conduct soil gas field analysis:

- Portable PID or FID
- Calibration gas standards of known concentration as specified in SOP FO.15, Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs)
- Split-spoon sampler, hand auger, or push type soil sampler (Geoprobe® or equivalent equipment)
- Wide-mouth sample jars with screw-cap lids
- Aluminum foil

##### 4.2.2 *Instrument Calibration and Operation*

PIDs and/or FIDs will be used in compliance with the procedures contained in SOP FO.15 Photoionization Detectors and

Flame Ionization Detectors. Instrument operational and calibration requirements will comply with the manufacture recommendations. Calibration of instruments involved in soil gas analysis shall occur at the beginning of each working day and, after that, continuing calibration verification shall be performed every eight hours or after a batch of 20 samples, whichever is more frequent.

A factor which will affect total organic vapor concentration measurements is the type of detector which is used (e.g., FID vs. PID); see Subsection 4.1.1 for discussion.

#### 4.2.3 *Sampling Procedure*

The following procedure will be used to measure those compounds present in the container headspace detectable by a FID/PID:

1. Collect soil sample using a split-spoon sampler, hand auger, or a push type sampler (Geoprobe® or equivalent) using a large bore or macro-core type sampler that will yield a soil core or intact sample. Be careful not to disturb the sample soil during sampling since doing so may release VOCs that are present. Half fill a wide-mouthed sample jar with the soil sample. Cover the container opening with aluminum foil and screw the jar lid down tightly. Granular soils should be broken apart by shaking the jar. Cohesive soils should be broken by crushing the sample as it is placed in the jar, and quickly covering.
2. Let the sample sit for 1 hour at ambient temperature before taking a reading. If the sample is collected during cold weather when ambient temperatures are below 25°C, or if more immediate results are desired, the volatilization process should be accelerated by placing the container into a warm environment, such as near a vehicle's air heater or in a warm-water (70° F) bath for approximately 30 minutes.
3. Following the warming period, remove the jar lid and insert the probe of the FID or PID through the foil cap (by making a hole in the foil just large enough to accept the probe), and take a reading.

#### 4.3 In Situ Soil Gas Sampling

In situ soil gas sampling is performed by pulling air samples with a vacuum pump directly through a hollow probe in the ground. Analysis of samples can be accomplished by multiple methods. This technique allows for the identification and quantification of specific volatile organic compounds.



In situ soil gas samples can be collected by dynamic or passive methods. Dynamic soil gas sampling involves extracting a volume of soil gas from the ground and analyzing the sample. A hollow probe with a retractable point can be driven into the ground, and the soil gas sample withdrawn with a vacuum extraction pump. The major advantages of dynamic soil gas testing are rapid data availability and the ability to distinguish between soil and groundwater contamination sources by vertical soil gas profiling.

Passive soil gas sampling generally involves implanting adsorption devices in the shallow surface soil and allowing them to adsorb VOC vapors from the soil for a period of days or weeks. After exposure, the devices are dug out and sent to a laboratory for analysis. This sampling methodology is probably the least expensive, but requires a considerable amount of time, and is less versatile than dynamic sampling methods.

Pertinent site-specific and compound-specific factors, which influence the collection and interpretation of soil gas, are required to be identified and evaluated in order to develop a comprehensive sampling program.

Sampling along an established grid is recommended at sites where the source(s) or general orientation of a subsurface plume are unknown. Where data are available which identify the source areas or plume characteristics, delineation of contaminant edges is most effectively achieved by establishing a transect parallel to the direction of groundwater flow and sampling outward from the suspected source. Soil gas probes should not be located less than 50 feet apart because the resolution of most soil gas detection techniques can be exceeded.

In order to effectively design the soil gas surveys and interpret the results, the subsurface transport and fate of VOCs should be considered. These factors can have a significant effect on the presence and concentration of VOCs in the soil atmosphere. Both physical and microbiological processes can influence soil gas investigations.

Partitioning of the contaminant between gaseous and aqueous phases is the physical process that permits contaminants mixed with water below the surface to be detected in soil gas. The air-water-partitioning coefficient can be dependent on both the vapor pressure and aqueous solubility of a compound. Generally, low molecular weight organic compounds (i.e., hydrocarbons, halogenated hydrocarbons, and ketones) are most readily detected in soil gas. Compounds possessing vapor pressures less than 1 mm Hg at 25°C will probably not be detected in soil gas. Vapor pressures provide an estimate of the diffusion coefficient and, thus, the "mobility" of the compound in the gas phase.

Soil gas analyses are highly quantitative and specific for individual compounds, but the extrapolation to groundwater contaminant concentrations are not quantitative. Soil gas measurements usually represent an indirect measure of the parameter of interest (e.g., groundwater plumes, extractable hydrocarbon concentrations in soil, sources of subsurface

leaks). Variables such as geology, soil moisture content, and the air-water-partitioning coefficient of the particular contaminant all affect the relationship between soil gas concentrations and groundwater contaminant concentrations. Water either in the vadose zone (i.e., very wet clay or a perched water zone) or in the saturated zone (a contaminated zone below clean water), is the major impediment to vapor movement. Soil gas techniques are relatively ineffective for confined aquifers or soils overlain by strata that are impermeable to gas diffusion.

#### 4.3.1 *Dynamic Sampling*

Dynamic soil gas sampling investigations can be performed using either hand-driven or mechanically driven probes and relatively inexpensive field instruments or sophisticated laboratory equipment. These techniques require the installation of a probe or soil boring in the vadose zone of a soil followed by withdrawal of the soil gas by a vacuum pump. Soil gas samples may be collected in gas sample bags, syringes, or on adsorption media. Samples collected in gas sample bags or on adsorption media must be analyzed at a nearby or on-site laboratory due to short sample holding times. Syringe samples must be analyzed on location immediately after collection.

A procedure for sampling of soil gas and on-site volatile organic compound analysis by the modified EPA Method 502.2 is presented in the publication, *Volatile Organic Sampling and Analysis in Soil Gas, Soils, Water, and Atmosphere by Modified EPA 502.2*, Hydro Geo Chem Inc. A procedure to sample soil gas and on-site volatile organic compound analysis by the modified EPA method 524.2 is presented in the publication, *Walsh Standard Operating Procedures for Obtaining Volatile Organic Compound Analysis for Air and Soil Gas Samples by Thermal Desorption and Gas Chromatography/Mass Spectrometry*.

##### 4.3.1.1 Soil Gas Probe Installation

Dynamic or grab sampling techniques require the installation of a probe in the vadose zone of a soil followed by withdrawal of the soil gas by a vacuum extraction pump. At RFETS the preferred tool is a probe with a retractable point that can be pushed or hammered to depth using a Geoprobe® or equivalent type push type sampler. The advantage of this type probe is that it can be driven to the desired depth, the bottom tip opened by backing the probe off 6 inches, and a soil gas sample extracted by using a vacuum pump and related sampling equipment on board the Geoprobe® van. Samples can be taken at various depths by advancing the probe to a deeper depth, and repeating the process above. Push type samplers also have the capability of drilling through concrete or asphalt as required. Soil gas probes must be cleaned with steam or hot water and soap before use and between sample locations (see SOP RMRS/OPS-PRO.127, Field Decontamination Operations).

Soil gas sampling can also be performed in augered boreholes or through the center of hollow-stem augers by driving the

probe at least 2 feet deeper than the augered depth.

The following procedures apply when collecting soil gas samples.

1. Clear the location(s) to be sampled for utilities, cables, pipes, etc. according to the procedures in SOP RMRS/OPS-PRO.102, Borehole Clearing. Clear the surface area to be sampled of grass, leaves, and debris.
2. Using a manual or mechanical driver, drive a cleaned/decontaminated probe with drive pipe(s), as needed, into the ground to the desired depth (minimum is usually 3 feet). Probes placed in augured boreholes should be driven at least 2 feet deeper than the augured depth. If refusal occurs significantly before the sampling depth is reached, remove the probe. Clear another sampling point within 1 foot of the first point and drive a clean probe again. If refusal occurs, another site should be selected and cleared according to SOP/OPS-PRO.102.
3. Once the sampling depth is reached, an entry on the Soil Gas Survey Form (Form PRO.121D) and the Soil Gas Survey Map (Form PRO.121C) will be made denoting the depth, time, and location of the sample. The probe will then be lifted 6 inches, or as required for the tool being used, to expose the air sampling slots in the retractable drive point.
4. Attach the gas-sampling cap with tubing to the top of the probe/driving pipes.
5. Connect adapter tubing to the vacuum gauge on the low-pressure side of the vacuum pump. An in-line liquid trap, programmable mass flow controller equipped with a solenoid valve and timer are very useful additions, but are not required.
6. Run the vacuum pump before sample collection to purge the system and displace the ambient air in the soil gas probe, drive pipe(s), and tubing. The purge volume is calculated according to the probe manufactures recommendations.
7. Purge the probe and silicone rubber tube connecting system. The vacuum gauge installed on the low-pressure side of the vacuum pump will be used to evaluate whether a representative soil gas sample can be withdrawn from the subsurface. Generally, if the applied vacuum exceeds 12 inches of mercury, the soil is either water saturated or does not have a sufficient air-filled porosity to produce a meaningful sample.
8. Collect samples from the tubing/manifold on the low-pressure side of the vacuum pump.

9. Record the time the vacuum pump is operated before sample collection, and the pressure reading (vacuum gauge) of gas in the soil gas probe line at the time of sampling.
10. The drive pipe(s) and soil probe will be removed at each location after the soil gas has been analyzed. The hole will be backfilled with granular bentonite and hydrated with deionized or distilled water, to avoid creating a migration pathway. After the removal of the soil probe, the distance between the sampling location and a known point will be measured and recorded on the soil gas survey map (Form PRO.121C) and a flag left at the sampling location for subsequent surveying.

#### 4.3.1.2 Sampling for Total Organic Vapor Analysis

In the simplest sampling/analysis technique, an organic vapor monitor such as a PID or FID is used. A piece of tubing of appropriate length is attached to the probe gas sampling cap and the PID/FID. After purging the system a direct reading of the soil vapor gas total organic concentration may then be made after the PID or FID instrument has pumped sufficiently for the gas sample to reach the detector. The procedures covered under SOP FO.15, Photoionization Detectors and Flame Ionization Detectors will apply.

#### 4.3.1.3 Sample Collection for Laboratory Analysis

Sampling/analysis of grab samples may also be accomplished by pumping the soil gas from the probe and collecting the gas in a Tedlar® bag. Alternatively, the soil gas may be pumped through a charcoal or Tenax® trap. The VOCs in the soil gas are adsorbed onto the charcoal or Tenax®. These samples must then be analyzed at an on-site laboratory since the holding times for these collection methods are short (1 to 8 hours). Analytical methods typically include the use of gas chromatography (GC) and/or mass spectrometry (MS).

Specific analytical methods and calibration procedures, standards concentrations, detectors, temperature programs, etc. are dependent on the method of analysis and analytes of interest. Specific analytical methods and procedures will be detailed in applicable project work plans.

The procedures for sample collection are as follows:

1. Run the vacuum pump to purge the system and displace the ambient air in the soil gas probe, drive pipe(s), and tubing. Attach a gas collection bag and unclamp the flexible tubing, collecting the gas sample in the bag.

The bag will then be disconnected, sealed, and transported to the laboratory for analysis.

2. To collect a sample by adsorption, insert a Tenax® trap or other sampler into the sample chamber and attach it to the manifold after the probe and adapter system have been purged. Divert soil gas flow through the sample chamber. Record flow pressure, elapsed time, and volume of flow, if mass flow controller is used.

#### 4.3.1.4 Sample Collection for Field Gas Chromatographic Analysis

An alternative grab sampling technique requires soil gas to be pumped through the soil probe, collected with a syringe, and immediately injected into a field gas chromatograph or a gas chromatograph located near the sampling site. This method allows for real-time results, and is particularly useful.

The gas chromatograph will be operated according to the manufacture instructions, will require a power source and an enclosed area, appropriate calibration gas standards and required equipment to perform the calibration, and appropriate samples containers and septums

Samples are collected with a glass syringe by inserting the syringe into the extraction line near the top of the soil gas probe (intake side of the pump).

Specific analytical method calibration procedures, standards concentrations, detectors, temperature programs, etc. are dependent on the method of analysis and analytes of interest. Specific analytical methods and procedures will be detailed in applicable project work plans.

#### 4.3.2 *Passive Sampling*

While other passive techniques may be available, this procedure is directed toward the use of Petrex® tubes as the representative technique since their utility has been demonstrated in past studies at RFETS. The Petrex® passive sampling technique is a direct method for trapping and identifying VOCs emanating from either soil (vadose zone) or groundwater contaminated locations. The collector consists of highly sensitive sorbents (such as activated charcoal) chemically fused to the tip of a wire. The collectors are arrayed, generally in a grid pattern, throughout the survey site, normally at a depth of approximately 1 foot (see Figure PRO.121-1). The collectors reside for a measured period, which can range up to 30 days, to assure time-integrative gas collection (as opposed to instantaneous collection with grab samples). The collectors are retrieved following the time-integrative collection period, and are then sent to a laboratory for analysis by mass spectrometry.

The most critical aspect of collector placement is to prevent exposing the collector to contaminants other than those in the soil gas. The lip and inside of the tube, cap, and cap liner must not contact any contaminants. The tubes must be stored in a clean area away from contaminants, and nitrile or similar protective gloves should be worn when handling the collectors.

#### 4.3.2.1 Installation and Collection Procedures

1. Clear the surface area to be sampled for shallow utilities, cables, pipes, etc. (follow SOP/OPS-PRO.102 if necessary). Clear the area to be sampled of grass, leaves, or debris; be careful not to walk or drive over the area.
2. Using a cleaned/decontaminated tool, dig a sample location 10-12 inches deep and approximately 2-4 inches in diameter. Do not contaminate the soil. If refusal occurs significantly before the sampling depth is reached, remove and clean the tool. Clear another sampling point within 1 foot of the first point and attempt the hole again. If refusal occurs, eliminate the area within 10 square feet as a sampling point.
3. Unwrap a Petrex sampling tube and remove the cap and black seal liner. Immediately place the sampler (vertically with open end down) into the sample location hole. The sampler tube must be at least 2 inches below ground surface. Immediately cover the sampler with soil (see FigurePRO.121-1).
4. If the black liner has come out of the cap, replace it and return the cap to one of the clean plastic bags provided.
5. Mark the sample location with flagging or other type of locator. Note the sample location on a base map and enter information on Form PRO.121C, and in a field notebook.
6. Retrieving samples - (should be done at recommended time interval).
  - a) Remove the soil until the tube is exposed.
  - b) Take the cap from sealed plastic bag. Check for the black liner inside the cap. If the liner has fallen out, replace it.
  - c) Remove the tube from the hole. If the wire falls out of the tube or if the tube is broken, use tweezers to handle the wires.

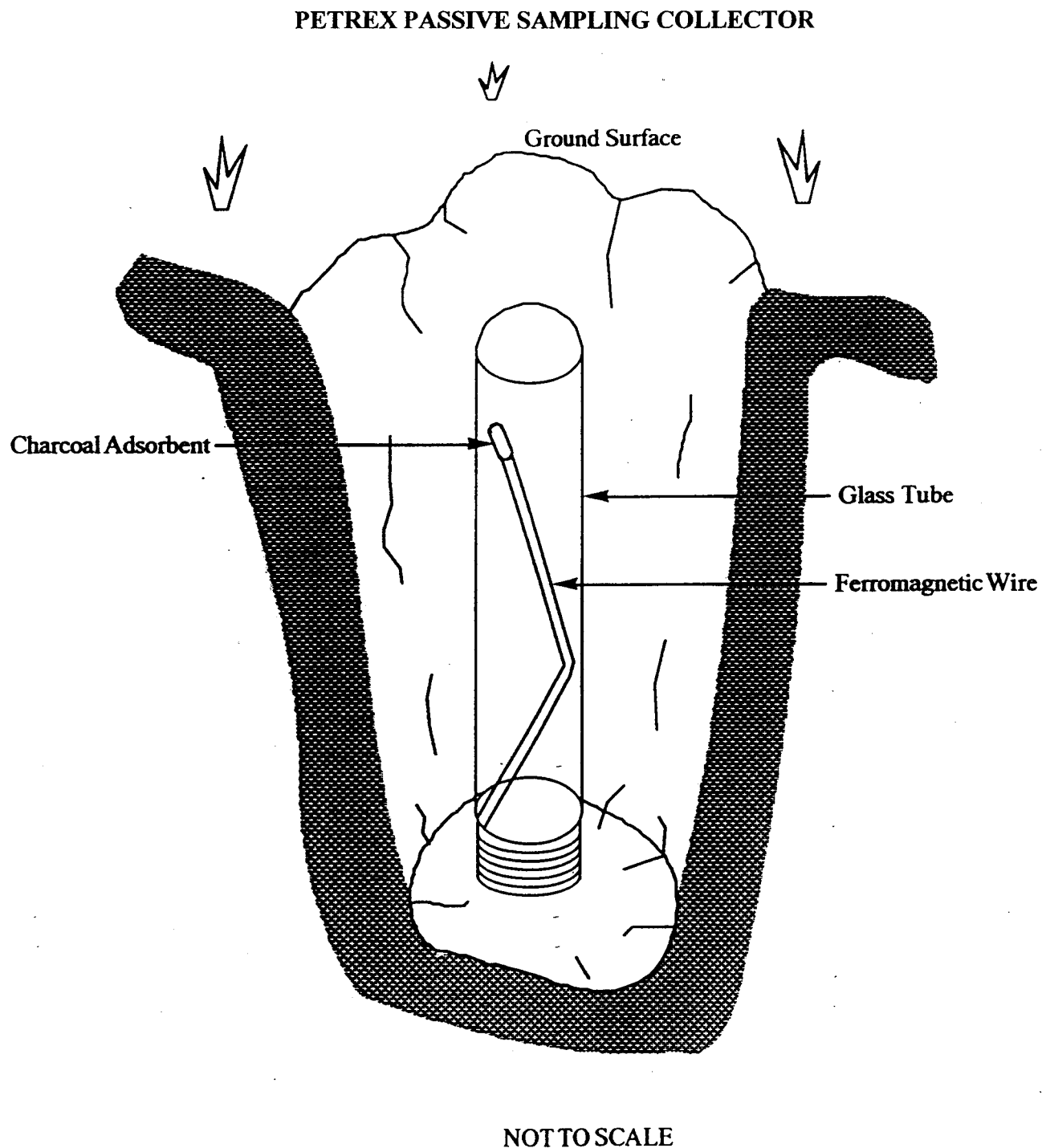


FIGURE PRO.121-1

- d) Wipe off the tube and threads thoroughly with a clean, dry cloth. If the tube threads and lip are not properly cleaned, the cap will not seal and the sample will become contaminated.
  - e) Seal the tube with a cap making sure the black liner is seated to the tube lip. If the cap does not thread easily, use a different cap. Cap must be sealed tightly against liner.
  - f) Place a sticker on the cap top and number it. Number sequentially starting with 1. Use only numbers to identify samples. Use only one number per tube. Underline all numbers for easy identification. Do not duplicate cap numbers. The Petrex tube distributor will number all second and third wire tubes appropriately.
  - g) Record the number or numbers of the sampler corresponding to the location on the base map and field notebook. Also, record in field notes any samples that have more than one wire per tube.
  - h) Do not place tape, sticker, or glue on the glass tube. Stickers provided will adhere if placed on a dry cap.
7. When packaging exposed tubes, do not use styrofoam or popcorn packing as this can potentially introduce a contaminant. Enclose tubes in two plastic bags and wrap each package tightly with bubble wrap. Complete appropriate submittal forms, provided by supplier, to be shipped with samples. Samples are to be placed in sealed containers. Packaging, labeling, and preparation procedures for shipment are specified in SOP RMRS/OPS-PRO-069, Containing, Preserving, Handling, and Shipping Soil and Water Samples.

## 5.0 QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance (QA) and Quality Control (QC) activities will be accomplished according to the project-specific Quality Assurance Addendum (QAA).

In addition to adhering to the requirements of the site-specific Field Sampling Plan (FSP) and any supplementary site-specific procedures, the minimum QA/QC requirements for this sampling activity are the following:

- QC Samples -- The number and types of QC samples including duplicate samples, field blanks, equipment blanks, and trip blanks will be collected or prepared as specified in the QAA.



- Verification -- Verification activities are required for the above practices, including surveillance and periodic record audits. These activities will be documented and become part of the completed project records.

#### 5.1 QA/QC SAMPLES FOR FIELD GC ANALYSIS

Frequency of calibration, method blanks, replicates, etc. are dependent upon project Data Quality Objectives (DQOs), and must be addressed in the project-specific Quality Assurance Addendum (QAA). Calibration of instruments involved in soil gas analysis shall occur at the beginning of each working day and, after that, continuing calibration verification shall be performed every eight hours or after a batch of 20 samples, whichever is more frequent. Soil gas analysis should address an adequate level of precision. Soil gas precision values for analysis of duplicate samples can exceed a relative percent difference of 40 percent. Relative percent difference values for duplicate samples will be within the 40% range unless stated otherwise in the project specific work plan.

#### 6.0 DOCUMENTATION

For each soil gas location, a permanent record of the implementation of this SOP will be kept by documenting field observations and data. Observations and data will be recorded with black waterproof (permanent) ink on the attached forms; the Photoionization Detector Field Data Form (Form PRO.121A), the Flame Ionization Field Data Form (Form PRO.121B), the Soil Gas Survey Map (Form PRO.121C), and the Soil Gas Survey Form (Form PRO.121D). Observations may also be documented in a bound weatherproof field notebook with consecutively numbered pages. This information will include the following:

- Sampler's name (form)
- Date and time of sample collection (form)
- Sampling identification (form)
- Weather conditions (notebook)
- Sampling depth (form)
- Driving characteristics of the soil probe (notebook)
- Description of the surface features (drainage, facilities, etc.), soils, any contamination noted, and trenches or any other feature that may impact the soil gas measurement (notebook)
- Vacuum pressure when extracting a sample (form)
- Type of sample (gas, liquid, or mixed) (form)
- Compounds and concentration of the organics measured on the GC and any replicate or blank

analysis performed (form)

- All calibrations performed (form)
- Any unusual responses of the instrument (form)
- Length of time the vacuum was applied to the sample probe before a sample was taken (notebook)
- Estimated concentration and recorded retention time of all chromatographic peaks, including those that represent unknown compounds (GC chromatographs)
- Estimated concentration and recorded retention time of all chromatographic peaks, including those that represent unknown compounds (GC chromatographs)

## 7.0 REFERENCES

### 7.1 SOURCE REFERENCES

The following is a list of references reviewed prior to the writing of this procedure:

A Compendium of Superfund Field Operations Methods. EPA/540/P-87/001. December 1987.

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## 7.2 INTERNAL REFERENCES

Related SOPs cross-referenced by this SOP are as follows:

- SOP RMRS/OPS-PRO.069, Containing, Preserving, Handling, and Shipping Soil and Water Samples
- SOP RMRS/OPS-PRO.102, Borehole Clearing
- SOP RMRS/OPS-PRO.127, Field Decontamination Operations
- SOP FO.15, Photoionization Detectors and Flame Ionization Detectors

**FORM PRO.121A (REV. 0)**

### PHOTOIONIZATION DETECTOR FIELD DATA

Facility Code _____	Log Date _____
Location ID _____	Location Type _____
Logger Code _____	Field Rep _____
Photoionization Detector Instrument	Serial No. _____
Manufacturer _____	Model _____
Date/Time Calibrated _____	Acceptance Code _____

## TYPE/CYLINDER NO.

CONCENTRATION (PPM)/SPAN

1

1

2

2

Comments:

[illegible]

Acceptance Codes: A-Acceptable R-Reconnaissance U-Unacceptable N-Not Determined

**Location Types:** SB - Sample Bottle  
BH - Borehole SL - Surface Location  
TP - Test Pit WL - Well  
SS - Soil Sample OT - Other

Observed Reading:  
DH - Downhole BZ - Breathing Zone  
HS - Headspace D - During Drilling  
OT - Other

**Completed By:** \_\_\_\_\_

Print Name	Signature	Date
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Subcontractor: \_\_\_\_\_

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**FORM PRO.121B (REV. 0)**

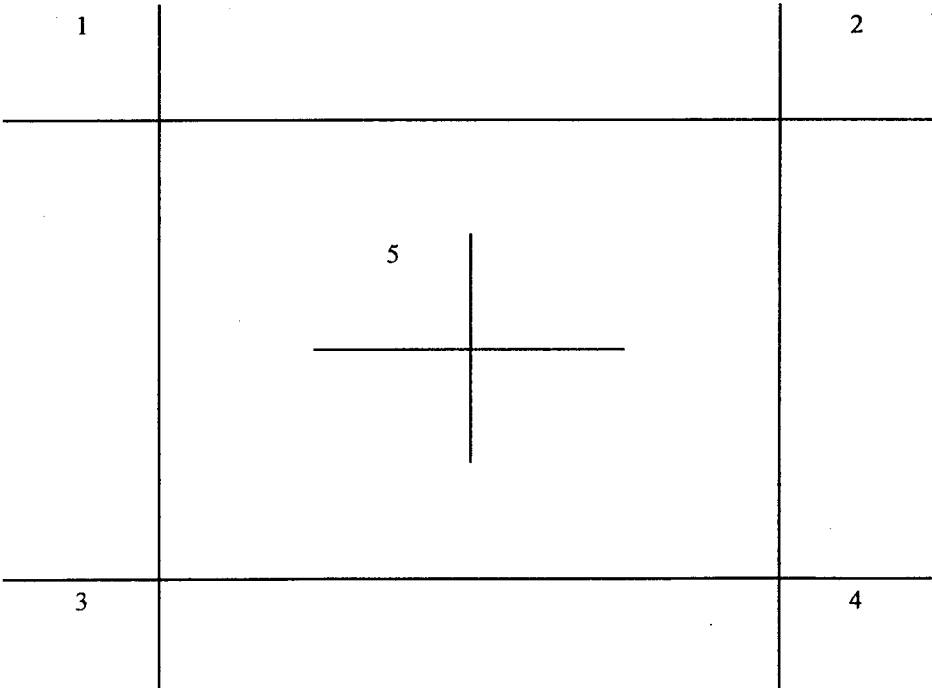
FLAME IONIZATION DETECTOR FIELD DATA								
Facility Code _____				Log Date _____				
Location ID _____				Location Type _____				
Logger Code _____				Field Rep _____				
Flame Ionization Detector Instrument:				Serial No. _____				
Manufacturer _____				Model _____				
Date/Time Calibrate _____				Acceptance Code _____				
CALIBRATION GASES:								
TYPE/CYLINDER NO.				CONCENTRATION (PPM)				
1				1				
2				2				
Comments:								
Time (HH:MM)	Drilling Depth (ft)	Observed Reading (ppm)					Sample ID	Comments
		DH	HS	EZ	D	OT		
Acceptance Codes: A-Acceptable R-Reconnaissance U-Unacceptable N-Not Determined								
Location Types: BH - Borehole TP - Test Pit SS - Soil Sample		SB - Sample Bottle SL - Surface Location WL - Well OT - Other		Observed Reading: DH - Downhole BZ - Breathing Zone HS - Headspace D - During Drilling OT - Other				

Subcontractor: \_\_\_\_\_

## ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

FORM PRO.121C (REV. 0)

## SOIL GAS SURVEY MAP

OU No: _____ IHSS No: _____ Date: _____	
Sample Team Members: _____ _____ _____	
<b>GRID BLOCK</b>  	
<b>Coordinates:</b> 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ 7 _____ 8 _____	

Completed By: \_\_\_\_\_  
Print Name Signature date

Subcontractor: \_\_\_\_\_

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**FORM PRO.121D (REV. 0)**

[illegible]

Date \_\_\_\_\_

Subcontractor: